MISSILE TECHNOLOGY CONTROL REGIME

(M.T.C.R.)

EQUIPMENT, SOFTWARE AND TECHNOLOGY ANNEX

29th May 2019

The agreed changes are shown in bold in the following Items: **3.A.1., 3.A.2.** and **15.B.3.** An agreed deletion affects Item **12.A.1.**

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INTRODUCTION, DEFINITIONS, TERMINOLOGY

1. INTRODUCTION

(a) This Annex consists of two categories of items, which term includes equipment, materials, "software" or "technology". Category I items, all of which are in Annex Items 1 and 2, are those items of greatest sensitivity. If a Category I item is included in a system, that system will also be considered as Category I, except when the incorporated item cannot be separated, removed or duplicated. Category II items are those items in the Annex not designated Category I.

(b) In reviewing the proposed applications for transfers of complete rocket and unmanned aerial vehicle systems described in Items 1 and 19, and of equipment, materials, "software" or "technology" which is listed in the Technical Annex, for potential use in such systems, the Government will take account of the ability to trade off "range" and "payload".

(c) General Technology Note:
The transfer of "technology" directly associated with any goods controlled in the Annex is controlled according to the provisions in each Item to the extent permitted by national legislation. The approval of any Annex item for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance, or repair of the item.

Note:

Controls do not apply to "technology" "in the public domain" or to "basic scientific research".

(d) General Software Note:

The Annex does not control "software" which is either:
1. Generally available to the public by being:
   a. Sold from stock at retail selling points without restriction, by means of:
      1. Over-the-counter transactions; or
      2. Mail order transactions; or
      3. Electronic transactions; or
      4. Telephone call transactions; and

b. Designed for installation by the user without further substantial support by the supplier; or

2. "In the public domain".

Note:

The General Software Note only applies to general purpose, mass market "software".

(e) General Minimum Software Note:

The approval of any Annex item for export also authorizes the export, or transfer, to the same end user of the minimum "software", excluding source code, required for the installation, operation, maintenance or repair of the item in order to ensure the item's safe operation as originally intended.

Note:

The General Minimum Software Note also authorizes export of "software" intended to correct defects (bug fixes) in a previously legally exported item, provided that the capability and/or performance of the item are not otherwise enhanced.

(f) Chemical Abstracts Service (CAS) Numbers:

In some instances chemicals are listed by name and CAS number. Chemicals of the same structural formula (including hydrates) are controlled regardless of name or CAS number. CAS numbers are shown to assist in identifying whether a particular chemical or mixture is controlled, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.

2. DEFINITIONS

For the purpose of this Annex, the following definitions apply:

"Accuracy"
Usually measured in terms of inaccuracy, means the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

"Basic scientific research"
Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

"Development"
Is related to all phases prior to "production" such as:
- design
- design research
- design analysis
- design concepts
- assembly and testing of prototypes
- pilot production schemes
- design data
- process of transforming design data into a product
- configuration design
- integration design
- layouts

"In the public domain"
This means "software" or "technology" which has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove "software" or "technology" from being "in the public domain".)

"Microcircuit"
A device in which a number of passive and/or active elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

"Microprograms"
A sequence of elementary instructions maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction register.

"Payload"

The total mass that can be carried or delivered by the specified rocket system or unmanned aerial vehicle (UAV) system that is not used to maintain flight.

Note:

The particular equipment, subsystems, or components to be included in the "payload" depends on the type and configuration of the vehicle under consideration.

Technical Notes:

1. Ballistic Missiles

a. "Payload" for systems with separating re-entry vehicles (RVs) includes:
1. The RVs, including:
a. Dedicated guidance, navigation, and control equipment;
b. Dedicated countermeasures equipment;
2. Munitions of any type (e.g. explosive or non-explosive);
3. Supporting structures and deployment mechanisms for the munitions (e.g. hardware used to attach to, or separate the RV from, the bus/post-boost vehicle) that can be removed without violating the structural integrity of the vehicle;
4. Mechanisms and devices for safing, arming, fuzing or firing;
5. Any other countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that separate from the RV bus/post-boost vehicle;
6. The bus/post-boost vehicle or attitude control/velocity trim module not including systems/subsystems essential to the operation of the other stages.

b. "Payload" for systems with non-separating re-entry vehicles includes:
1. Munitions of any type (e.g. explosive or non-explosive);
2. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;

3. Mechanisms and devices for safing, arming, fuzing or firing;
4. Any countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle.

2. Space Launch Vehicles

"Payload" includes:
a. Spacecraft (single or multiple), including satellites;
b. Spacecraft-to-launch vehicle adapters including, if applicable, apogee/perigee kick motors or similar manoeuvering systems and separation systems.

3. Sounding Rockets

"Payload" includes:
a. Equipment required for a mission, such as data gathering, recording or transmitting devices for mission-specific data;
b. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.

4. Cruise Missiles

"Payload" includes:
a. Munitions of any type (e.g. explosive or non-explosive);
b. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;
c. Mechanisms and devices for safing, arming, fuzing or firing;
d. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;
e. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle.

5. Other UAVs

"Payload" includes:
a. Munitions of any type (e.g. explosive or non-explosive);
b. Mechanisms and devices for safing, arming, fuzing or firing;

c. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;
d. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle;
e. Equipment required for a mission such as data gathering, recording or transmitting devices for mission-specific data and supporting structures that can be removed without violating the structural integrity of the vehicle;
f. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.
g. Munitions supporting structures and deployment mechanisms that can be removed without violating the structural integrity of the vehicle.

"Production"
Means all production phases such as:
- production engineering
- manufacture
- integration
- assembly (mounting)
- inspection
- testing
- quality assurance

"Production equipment"
Means tooling, templates, jigs, mandrels, moulds, dies, fixtures, alignment mechanisms, test equipment, other machinery and components therefor, limited to those specially designed or modified for "development" or for one or more phases of "production".

"Production facilities"
Means "production equipment" and specially designed "software" therefor integrated into installations for "development" or for one or more phases of "production".

"Programs"
A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Radiation hardened"
Means that the component or equipment is designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of 5×10^5 rads (Si).

"Range"
The maximum distance that the specified rocket system or unmanned aerial vehicle (UAV) system is capable of travelling in the mode of stable flight as measured by the projection of its trajectory over the surface of the Earth.

Technical Notes:

1. *The maximum capability based on the design characteristics of the system, when fully loaded with fuel or propellant, will be taken into consideration in determining "range".*

2. *The "range" for both rocket systems and UAV systems will be determined independently of any external factors such as operational restrictions, limitations imposed by telemetry, data links or other external constraints.*

3. *For rocket systems, the "range" will be determined using the trajectory that maximises "range", assuming ICAO standard atmosphere with zero wind.*

4. *For UAV systems, the "range" will be determined for a one-way distance using the most fuel-efficient flight profile (e.g. cruise speed and altitude), assuming ICAO standard atmosphere with zero wind.*

"Software"
A collection of one or more "programs", or "microprograms", fixed in any tangible medium of expression.

"Technology"
Means specific information which is required for the "development", "production" or "use" of a product. The information may take the form of "technical data" or "technical assistance".

"Technical assistance"
May take forms such as:
- instruction
- skills

- training
- working knowledge
- consulting services

"Technical data"
May take forms such as:
- blueprints
- plans
- diagrams
- models
- formulae
- engineering designs and specifications
- manuals and instructions written or recorded on other media or devices such as:
  - disk
  - tape
  - read-only memories

"Use"
Means:
- operation
- installation (including on-site installation)
- maintenance
- repair
- overhaul
- refurbishing

3. TERMINOLOGY

Where the following terms appear in the text, they are to be understood according to the explanations below:

(a) "Specially designed" describes equipment, parts, components, materials or "software" which, as a result of "development", have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has no other function or use. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such if it is not capable of producing other types of components.

(b) "Designed or modified" describes equipment, parts or components which, as a result of "development," or modification, have specified properties that make them fit for a particular application. "Designed or modified" equipment, parts, components or "software" can be used for other applications. For example, a titanium coated pump designed for a missile may be used with corrosive fluids other than propellants.

(c) "Usable in", "usable for", "usable as" or "capable of" describes equipment, parts, components, materials or "software" which are suitable for a particular purpose. There is no need for the equipment, parts, components or "software" to have been configured, modified or specified for the particular purpose. For example, any military specification memory circuit would be "capable of" operation in a guidance system.

(d) "Modified" in the context of "software" describes "software" which has been intentionally changed such that it has properties that make it fit for specified purposes or applications. Its properties may also make it suitable for purposes or applications other than those for which it was "modified".

CATEGORY I

ITEM 1 COMPLETE DELIVERY SYSTEMS

1.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

1.A.1. Complete rocket systems (including ballistic missiles, space launch vehicles, and sounding rockets) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.

1.A.2. Complete unmanned aerial vehicle systems (including cruise missiles, target drones and reconnaissance drones) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.

1.B. TEST AND PRODUCTION EQUIPMENT

1.B.1. "Production facilities" specially designed for the systems specified in 1.A.

1.C. MATERIALS

None.

1.D. SOFTWARE

1.D.1. "Software" specially designed or modified for the "use" of "production facilities" specified in 1.B.

1.D.2. "Software" specially designed or modified to coordinate the function of more than one subsystem in systems specified in 1.A.

Note:

For a manned aircraft converted to operate as an unmanned aerial vehicle specified in 1.A.2., Item 1.D.2. includes "software", as follows:

a. "Software" specially designed or modified to integrate the conversion equipment with the aircraft system functions;

b. "Software" specially designed or modified to operate the aircraft as an unmanned aerial vehicle.

1.E. TECHNOLOGY

1.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 1.A., 1.B., or 1.D.

ITEM 2 COMPLETE SUBSYSTEMS USABLE FOR COMPLETE DELIVERY SYSTEMS

2.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

2.A.1. Complete subsystems usable in the systems specified in 1.A., as follows:

a. Individual rocket stages usable in the systems specified in 1.A.;

b. Re-entry vehicles usable in the systems specified in 1.A., and, as follows, equipment designed or modified therefor, except as provided in the Note below 2.A.1. for those designed for non-weapon payloads:
1. Heat shields, and components therefor, fabricated of ceramic or ablative materials;
2. Heat sinks and components therefor, fabricated of light-weight, high heat capacity materials;
3. Electronic equipment specially designed for re-entry vehicles;

c. Rocket propulsion subsystems, usable in the systems specified in 1.A., as follows;
1. Solid propellant rocket motors or hybrid rocket motors having a total impulse capacity equal to or greater than 1.1×10^6 Ns;
2. Liquid propellant rocket engines or gel propellant rocket motors integrated, or designed or modified to be integrated, into a liquid propellant or gel propellant propulsion system which has a total impulse capacity equal to or greater than 1.1×10^6 Ns;

Note:

Liquid propellant apogee engines or station-keeping engines specified in 2.A.1.c.2., designed or modified for use on satellites, may be treated as Category II, if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above, when having a vacuum thrust not greater than 1kN.

d. 'Guidance sets', usable in the systems specified in 1.A., capable of achieving system accuracy of 3.33% or less of the "range" (e.g. a 'CEP' of 10 km or less at a "range" of 300 km), except as provided in the Note

below 2.A.1. for those designed for missiles with a "range" under 300 km or manned aircraft;

Technical Notes:

1. *A 'guidance set' integrates the process of measuring and computing a vehicle's position and velocity (i.e. navigation) with that of computing and sending commands to the vehicle's flight control systems to correct the trajectory.*

2. *'CEP' (circle of equal probability) is a measure of accuracy, defined as the radius of the circle centred at the target, at a specific range, in which 50% of the payloads impact.*

e. Thrust vector control subsystems, usable in the systems specified in 1.A., except as provided in the Note below 2.A.1. for those designed for rocket systems that do not exceed the "range"/"payload" capability of systems specified in 1.A.;

Technical Note:

2.A.1.e. includes the following methods of achieving thrust vector control:
a. Flexible nozzle;
b. Fluid or secondary gas injection;
c. Movable engine or nozzle;
d. Deflection of exhaust gas stream (jet vanes or probes);
e. Use of thrust tabs.

f. Weapon or warhead safing, arming, fuzing, and firing mechanisms, usable in the systems specified in 1.A., except as provided in the Note below 2.A.1. for those designed for systems other than those specified in 1.A.

Note:

The exceptions in 2.A.1.b., 2.A.1.d., 2.A.1.e. and 2.A.1.f. above may be treated as Category II if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above.

2.B. TEST AND PRODUCTION EQUIPMENT

2.B.1. "Production facilities" specially designed for the subsystems specified in 2.A.

2.B.2. "Production equipment" specially designed for the subsystems specified in 2.A.

2.C. MATERIALS

None.

2.D. SOFTWARE

2.D.1. "Software" specially designed or modified for the "use" of "production facilities" specified in 2.B.1.

2.D.2. "Software" specially designed or modified for the "use" of rocket motors or engines specified in 2.A.1.c.

2.D.3. "Software", specially designed or modified for the operation or maintenance of 'guidance sets' specified in 2.A.1.d.

Note:

2.D.3. includes "software", specially designed or modified to enhance the performance of 'guidance sets' to achieve or exceed the accuracy specified in 2.A.1.d.

2.D.4. "Software" specially designed or modified for the operation or maintenance of subsystems or equipment specified in 2.A.1.b.3.

2.D.5. "Software" specially designed or modified for the operation or maintenance of subsystems in 2.A.1.e.

2.D.6. "Software" specially designed or modified for the operation or maintenance of subsystems in 2.A.1.f.

Note:

Subject to end-use statements appropriate for the excepted end-use, "software" controlled by 2.D.2. - 2.D.6. may be treated as Category II as follows:

1. Under 2.D.2. if specially designed or modified for liquid propellant apogee engines or station keeping engines, designed or modified for satellite applications as specified in the Note to 2.A.1.c.2.;

2. Under 2.D.3. if designed for missiles with a "range" of under 300 km or manned aircraft;

3. Under 2.D.4. if specially designed or modified for re-entry vehicles designed for non-weapon payloads;

4. Under 2.D.5. if designed for rocket systems that do not exceed the "range" "payload" capability of systems specified in 1.A.;

5. Under 2.D.6. if designed for systems other than those specified in 1.A.

2.E. TECHNOLOGY

2.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 2.A., 2.B. or 2.D.

CATEGORY II

ITEM 3 PROPULSION COMPONENTS AND EQUIPMENT

3.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

3.A.1. Turbojet and turbofan engines, as follows:

a. Engines having all of the following characteristics:
1. 'Maximum thrust value' greater than 400 N excluding civil certified engines with a 'maximum thrust value' greater than 8.89 kN;
2. Specific fuel consumption of 0.15 kg N^{-1} h^{-1} or less;
3. 'Dry weight' less than 750 kg; and
4. 'First-stage rotor diameter' less than 1 m;

Technical Notes:

1. *'**M**aximum thrust value' is the manufacturer's demonstrated maximum thrust for the engine type un-installed at sea level static conditions using the ICAO standard atmosphere. The civil type certified thrust value will be equal to or less than the manufacturer's demonstrated maximum thrust for the engine type **un-installed**.*
2. ***Specific fuel consumption is determined at maximum continuous thrust for engine type un-installed at sea level static conditions using the ICAO standard atmosphere.***
3. *'Dry weight' is the weight of the engine without fluids (fuel, hydraulic fluid, oil, etc.) and does not include the nacelle (housing).*
4. *'First-stage rotor diameter' is the diameter of the first rotating stage of the engine, whether a fan or compressor, measured at the leading edge of the blade tips.*

b. Engines designed or modified for systems specified in 1.A. or 19.A.2., regardless of thrust, specific fuel consumption, 'dry weight' or 'first-stage rotor diameter'.

Note:

Engines specified in 3.A.1. may be exported as part of a manned aircraft or in quantities appropriate for replacement parts for a manned aircraft.

3.A.2. Ramjet, scramjet, pulse jet, detonation, or 'combined cycle' engines, including devices to regulate combustion, and specially designed components therefor, usable in the systems specified in 1.A. or 19.A.2.

Technical Notes:

1. In Item 3.A.2., 'combined cycle' engine is the engine that employs two or more cycles of the following engine types: gas-turbine (turbojet, turboprop, turbofan and turboshaft), ramjet, scramjet, pulse jet, detonation or rocket motor or rocket engine (liquid, gel, solid propellant and hybrid).

2. In Item 3.A.2., detonation engines utilise detonation to produce a rise in effective pressure across the combustion chamber. Examples of detonation engines include pulse detonation engines, rotating detonation engines or continuous wave detonation engines.

3.A.3. Rocket motor cases, 'insulation' components and nozzles for solid propellant or hybrid rocket motors usable in the subsystems specified in 2.A.1.c.1. or 20.A.1.b.1.

Technical Note:

In 3.A.3. 'insulation' intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber components comprising sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps.

Note:

Refer to 3.C.2. for 'insulation' material in bulk or sheet form.

3.A.4. Staging mechanisms, separation mechanisms, and interstages therefor, usable in the systems specified in 1.A.

Note:

See also Item 11.A.5.

Technical Note:

Staging and separation mechanisms specified in 3.A.4. may contain some of the following components:

- *Pyrotechnic bolts, nuts and shackles;*
- *Ball locks;*
- *Circular cutting devices;*
- *Flexible linear shaped charges (FLSC).*

3.A.5. Liquid, slurry and gel propellant (including oxidisers) control systems, and specially designed components therefor, usable in the systems specified in 1.A., designed or modified to operate in vibration environments greater than 10 g rms between 20 Hz and 2 kHz.

Notes:

1. The only servo valves, pumps and gas turbines specified in 3.A.5. are the following:
a. Servo valves designed for flow rates equal to or greater than 24 litres per minute, at an absolute pressure equal to or greater than 7 MPa, that have an actuator response time of less than 100 ms.
b. Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 rpm at the maximum operating mode or with discharge pressures equal to or greater than 7 MPa.
c. Gas turbines, for liquid propellant turbopumps, with shaft speeds equal to or greater than 8,000 rpm at the maximum operating mode.

2. Systems and components specified in 3.A.5. may be exported as part of a satellite.

3.A.6. Specially designed components for hybrid rocket motors specified in 2.A.1.c.1. or 20.A.1.b.1.

3.A.7. Radial ball bearings having all tolerances specified in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or

other national equivalents), or better and having all of the following characteristics:

a. An inner ring bore diameter between 12 and 50 mm;

b. An outer ring outside diameter between 25 and 100 mm; and

c. A width between 10 and 20 mm.

3.A.8. Liquid or gel propellant tanks specially designed for the propellants controlled in Item 4.C. or other liquid or gel propellants used in the systems specified in 1.A.1.

3.A.9. 'Turboprop engine systems' specially designed for the systems in 1.A.2. or 19.A.2., and specially designed components therefor, having a maximum power greater than 10 kW (achieved uninstalled at sea level static conditions using the ICAO standard atmosphere), excluding civil certified engines.

Technical Note:

For the purposes of Item 3.A.9., a 'turboprop engine system' incorporates all of the following:
a. Turboshaft engine; and
b. Power transmission system to transfer the power to a propeller.

3.A.10. Combustion chambers and nozzles for liquid propellant rocket engines or gel propellant rocket motors usable in the subsystems specified in 2.A.1.c.2. or 20.A.1.b.2.

3.B. TEST AND PRODUCTION EQUIPMENT

3.B.1. "Production facilities" specially designed for equipment or materials specified in 3.A.1., 3.A.2., 3.A.3., 3.A.4., 3.A.5., 3.A.6., 3.A.8., 3.A.9., 3.A.10. or 3.C.

3.B.2. "Production equipment" specially designed for equipment or materials specified in 3.A.1., 3.A.2., 3.A.3., 3.A.4., 3.A.5., 3.A.6., 3.A.8., 3.A.9., 3.A.10. or 3.C.

3.B.3. Flow-forming machines, usable in the "production" of propulsion components and equipment (e.g. motor cases and interstages) for systems specified in 1.A., having all

of the following, and specially designed components therefor:

a. Equipped with, or according to the manufacturer's technical specification are capable of being equipped with, numerical control units or computer control; and

b. More than two axes which can be co-ordinated simultaneously for contouring control.

Technical Note:

Machines combining the function of spin-forming and flow-forming are, for the purpose of this item, regarded as flow-forming machines.

3.C. MATERIALS

3.C.1. 'Interior lining' usable for rocket motor cases in the subsystems specified in 2.A.1.c.1. or specially designed for subsystems specified in 20.A.1.b.1.

Technical Note:

In 3.C.1. 'interior lining' suited for the bond interface between the solid propellant and the case or insulating liner is usually a liquid polymer based dispersion of refractory or insulating materials e.g. carbon filled HTPB or other polymer with added curing agents to be sprayed or screeded over a case interior.

3.C.2. 'Insulation' material in bulk form usable for rocket motor cases in the subsystems specified in 2.A.1.c.1. or specially designed for subsystems specified in 20.A.1.b.1.

Technical Note:

In 3.C.2. 'insulation' intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps specified in 3.A.3.

3.D. SOFTWARE

3.D.1. "Software" specially designed or modified for the "use" of "production facilities" and flow-forming machines specified in 3.B.1. or 3.B.3.

3.D.2. "Software" specially designed or modified for the "use" of equipment specified in 3.A.1., 3.A.2., 3.A.4., 3.A.5., 3.A.6. or 3.A.9.

Notes:

1. "Software" specially designed or modified for the "use" of engines specified in 3.A.1. may be exported as part of a manned aircraft or as replacement "software" therefor.

2. "Software" specially designed or modified for the "use" of propellant control systems specified in 3.A.5. may be exported as part of a satellite or as replacement "software" therefor.

3.D.3. "Software" specially designed or modified for the "development" of equipment specified in 3.A.2., 3.A.3. or 3.A.4.

3.E. TECHNOLOGY

3.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 3.A.1., 3.A.2., 3.A.3., 3.A.4., 3.A.5., 3.A.6., 3.A.8., 3.A.9., 3.A.10., 3.B., 3.C. or 3.D.

ITEM 4 PROPELLANTS, CHEMICALS AND PROPELLANT PRODUCTION

4.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

None.

4.B. TEST AND PRODUCTION EQUIPMENT

4.B.1. "Production equipment", and specially designed components therefor, for the "production", handling or acceptance testing of liquid propellants or propellant constituents specified in 4.C.

4.B.2. "Production equipment", other than that described in 4.B.3., and specially designed components therefor, for the production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents specified in 4.C.

4.B.3. Equipment as follows, and specially designed components therefor:

a. Batch mixers having all of the following:
   1. Designed or modified for mixing under vacuum in the range of zero to 13.326 kPa;
   2. Capable of controlling the temperature of the mixing chamber;
   3. A total volumetric capacity of 110 litres or more; and
   4. At least one 'mixing/kneading shaft' mounted off centre;

   Note:

   In Item 4.B.3.a.4. the term 'mixing/kneading shaft' does not refer to deagglomerators or knife-spindles.

b. Continuous mixers having all of the following:
   1. Designed or modified for mixing under vacuum in the range of zero to 13.326 kPa;
   2. Capable of controlling the temperature of the mixing chamber; and
   3. Any of the following:
      a. Two or more mixing/kneading shafts; or
      b. All of the following:
         1. A single rotating and oscillating shaft with kneading teeth/pins; and

2. Kneading teeth/pins inside the casing of the mixing chamber;

c. Fluid energy mills usable for grinding or milling substances specified in 4.C.;

d. Metal powder "production equipment" usable for the "production", in a controlled environment, of spherical, spheroidal or atomised materials specified in 4.C.2.c., 4.C.2.d. or 4.C.2.e.

Note:

4.B.3.d. includes:
a. Plasma generators (high frequency arc-jet) usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
b. Electroburst equipment usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
c. Equipment usable for the "production" of spherical aluminium powders by powdering a melt in an inert medium (e.g. nitrogen).

Notes:

1. The only batch mixers, continuous mixers, usable for solid propellants or propellants constituents specified in 4.C., and fluid energy mills specified in 4.B., are those specified in 4.B.3.

2. Forms of metal powder "production equipment" not specified in 4.B.3.d. are to be evaluated in accordance with 4.B.2.

4.C. MATERIALS

4.C.1. Composite and composite modified double base propellants.

4.C.2. Fuel substances as follows:

a. Hydrazine (*CAS 302-01-2*) with a concentration of more than 70%;

b. Hydrazine derivatives as follows:
1. Monomethylhydrazine (MMH) (*CAS 60-34-4*);

2. Unsymmetrical dimethylhydrazine (UDMH) (*CAS 57-14-7*);
3. Hydrazine mononitrate (*CAS 13464-97-6*);
4. Trimethylhydrazine (*CAS 1741-01-1*);
5. Tetramethylhydrazine (*CAS 6415-12-9*);
6. N,N diallylhydrazine (*CAS 5164-11-4*);
7. Allylhydrazine (*CAS 7422-78-8*);
8. Ethylene dihydrazine (*CAS 6068-98-0*);
9. Monomethylhydrazine dinitrate;
10. Unsymmetrical dimethylhydrazine nitrate;
11. Hydrazinium azide (*CAS 14546-44-2*);
12. 1,1-Dimethylhydrazinium azide (*CAS 227955-52-4*) / 1,2-Dimethylhydrazinium azide (*CAS 299177-50-7*);
13. Hydrazinium dinitrate (*CAS 13464-98-7*);
14. Diimido oxalic acid dihydrazine (*CAS 3457-37-2*);
15. 2-hydroxyethylhydrazine nitrate (HEHN);
16. Hydrazinium perchlorate (*CAS 27978-54-7*);
17. Hydrazinium diperchlorate (*CAS 13812-39-0*);
18. Methylhydrazine nitrate (MHN) (*CAS 29674-96-2*);
19. 1,1-Diethylhydrazine nitrate (DEHN) / 1,2-Diethylhydrazine nitrate (DEHN) (*CAS 363453-17-2*);
20. 3,6-dihydrazino tetrazine nitrate (DHTN);

<u>*Technical note:*</u>

3,6-dihydrazino tetrazine nitrate is also referred to as 1,4-dihydrazine nitrate.

c. Spherical or spheroidal aluminium powder (*CAS 7429-90-5*) in particle size of less than 200 x 10^{-6} m (200 µm) and an aluminium content of 97% by weight or more, if at least 10% of the total weight is made up of particles of less than 63 µm, according to ISO 2591-1:1988 or national equivalents;

<u>*Technical Note:*</u>

A particle size of 63 µm (ISO R-565) corresponds to 250 mesh (Tyler) or 230 mesh (ASTM standard E-11).

d. Metal powders of any of the following: zirconium (*CAS 7440-67-7*), beryllium (*CAS 7440-41-7*), magnesium (*CAS 7439-95-4*) or alloys of these, if at least 90% of the total particles by particle volume or weight are

made up of particles of less than 60 µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomised, spheroidal, flaked or ground, consisting of 97% by weight or more of any of the above mentioned metals;

Note:

In a multimodal particle distribution (e.g. mixtures of different grain sizes) in which one or more modes are controlled, the entire powder mixture is controlled.

Technical Note:

The natural content of hafnium (CAS 7440-58-6) in the zirconium (typically 2% to 7%) is counted with the zirconium.

e. Metal powders of either boron (*CAS 7440-42-8*) or boron alloys with a boron content of 85% or more by weight, if at least 90% of the total particles by particle volume or weight are made up of particles of less than 60 µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomised, spheroidal, flaked or ground;

Note:

In a multimodal particle distribution (e.g. mixtures of different grain sizes) in which one or more modes are controlled, the entire powder mixture is controlled.

f. High energy density materials, usable in the systems specified in 1.A. or 19.A., as follows:

1. Mixed fuels that incorporate both solid and liquid fuels, such as boron slurry, having a mass- based energy density of 40×10^6 J/kg or greater;

2. Other high energy density fuels and fuel additives (e.g., cubane, ionic solutions, JP-10) having a volume-based energy density of 37.5×10^9 J/m^3 or greater, measured at 20^{o}C and one atmosphere (101.325 kPa) pressure.

Note:

Item 4.C.2.f.2. does not control fossil refined fuels and biofuels produced from vegetables, including fuels for engines certified for use in civil aviation, unless specifically formulated for systems specified in 1.A. or 19.A.

g. Hydrazine replacement fuels as follows:

1. 2-Dimethylaminoethylazide (DMAZ) (*CAS 86147-04-8*).

4.C.3. Oxidisers/Fuels as follows:

a. Perchlorates, chlorates or chromates mixed with powdered metals or other high energy fuel components;
b. Hydroxylammonium nitrate (HAN) *(CAS 13465-08-2)*.

4.C.4. Oxidiser substances as follows:

a. Oxidiser substances usable in liquid propellant rocket engines as follows:
1. Dinitrogen trioxide (*CAS 10544-73-7*);
2. Nitrogen dioxide (*CAS 10102-44-0*) / dinitrogen tetroxide (*CAS 10544-72-6*);
3. Dinitrogen pentoxide (*CAS 10102-03-1*);
4. Mixed Oxides of Nitrogen (MON);

Technical Note:

Mixed Oxides of Nitrogen (MON) are solutions of Nitric Oxide (NO) in Dinitrogen Tetroxide/Nitrogen Dioxide (N_2O_4/NO_2) that can be used in missile systems. There are a range of compositions that can be denoted as MONi or MONij where i and j are integers representing the percentage of Nitric Oxide in the mixture (e.g. MON3 contains 3% Nitric Oxide, MON25 25% Nitric Oxide. An upper limit is MON40, 40% by weight).

5. Inhibited Red Fuming Nitric Acid (IRFNA) (*CAS 8007-58-7*);
6. Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen;

Note:

Item 4.C.4.a.6. does not control Nitrogen Trifluoride (NF_3) (CAS 7783-54-2) in a gaseous state as it is not usable for missile applications.

b. Oxidiser substances usable in solid propellant rocket motors as follows:
1. Ammonium perchlorate (AP) (*CAS 7790-98-9*);
2. Ammonium dinitramide (ADN) (*CAS 140456-78-6*);
3. Nitro-amines (cyclotetramethylene - tetranitramine (HMX) (*CAS 2691-41-0*); cyclotrimethylene - trinitramine (RDX) (*CAS 121-82-4*);
4. Hydrazinium nitroformate (HNF) (*CAS 20773-28-8*);
5. 2,4,6,8,10,12-Hexanitrohexaazaisowurtzitane (CL-20) (*CAS 135285-90-4*).

4.C.5. Polymeric substances, as follows:

a. Carboxy - terminated polybutadiene (including carboxyl - terminated polybutadiene) (CTPB);

b. Hydroxy - terminated polybutadiene (including hydroxyl - terminated polybutadiene) (HTPB) (*CAS 69102-90-5*);

c. Glycidyl azide polymer (GAP), including hydroxyl - terminated GAP;

d. Polybutadiene - Acrylic Acid (PBAA);

e. Polybutadiene - Acrylic Acid - Acrylonitrile (PBAN) (*CAS 25265-19-4 / CAS 68891-50-9*);

f. Polytetrahydrofuran polyethylene glycol (TPEG).

Technical Note:

Polytetrahydrofuran polyethylene glycol (TPEG) is a block co-polymer of poly 1,4-Butanediol (CAS 110-63-4) and polyethylene glycol (PEG) (CAS 25322-68-3).

g. Polyglycidyl nitrate (PGN or poly-GLYN) (*CAS 27814-48-8*).

4.C.6. Other propellant additives and agents as follows:

a. Bonding agents as follows:
   1. Tris (1-(2-methyl)aziridinyl) phosphine oxide (MAPO) (*CAS 57-39-6*);
   2. 1,1′,1″-trimesoyl-tris(2-ethylaziridine) (HX-868, BITA) (*CAS 7722-73-8*);
   3. Tepanol (HX-878), reaction product of tetraethlylenepentamine, acrylonitrile and glycidol (*CAS 68412-46-4*);
   4. Tepan (HX-879), reaction product of tetraethlylenepentamine and acrylonitrile (*CAS 68412-45-3*);
   5. Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group;

   <u>*Note:*</u>

   Item 4.C.6.a.5. includes:
   1. 1,1'-Isophthaloyl-bis(2-methylaziridine) (HX-752) (CAS 7652-64-4);
   2. 2,4,6-tris(2-ethyl-1-aziridinyl)-1,3,5-triazine (HX-874) (CAS 18924-91-9);
   3. 1,1'-trimethyladipoylbis(2-ethylaziridine) (HX-877) (CAS 71463-62-2).

b. Curing reaction catalysts as follows:
   Triphenyl bismuth (TPB) (*CAS 603-33-8*);

c. Burning rate modifiers, as follows:
   1. Carboranes, decaboranes, pentaboranes and derivatives thereof;
   2. Ferrocene derivatives, as follows:
      a. Catocene (*CAS 37206-42-1*);
      b. Ethyl ferrocene (*CAS 1273-89-8*);
      c. n-Propyl ferrocene (*CAS 1273-92-3*) / iso-propyl ferrocene (*CAS 12126-81-7*);
      d. n-Butyl ferrocene (*CAS 31904-29-7*);
      e. Pentyl ferrocene (*CAS 1274-00-6*);
      f. Dicyclopentyl ferrocene (*CAS 125861-17-8*);
      g. Dicyclohexyl ferrocene;
      h. Diethyl ferrocene (*CAS 1273-97-8*);
      i. Dipropyl ferrocene;
      j. Dibutyl ferrocene (*CAS 1274-08-4*);
      k. Dihexyl ferrocene (*CAS 93894-59-8*);

l. Acetyl ferrocene (*CAS 1271-55*-2) / 1,1'-diacetyl ferrocene (*CAS 1273-94-5*);
m. Ferrocene carboxylic acid (*CAS 1271-42-7*) / 1,1'-Ferrocenedicarboxylic acid (*CAS 1293-87-4*);
n. Butacene (*CAS 125856-62-4*);
o. Other ferrocene derivatives usable as rocket propellant burning rate modifiers;

Note:

Item 4.C.6.c.2.o does not control ferrocene derivatives that contain a six carbon aromatic functional group attached to the ferrocene molecule.

d. Esters and plasticisers as follows:
1. Triethylene glycol dinitrate (TEGDN) (*CAS 111-22-8*);
2. Trimethylolethane trinitrate (TMETN) (*CAS 3032-55-1*);
3. 1,2,4-butanetriol trinitrate (BTTN) (*CAS 6659-60-5*);
4. Diethylene glycol dinitrate (DEGDN) (*CAS 693-21-0*);
5. 4,5 diazidomethyl-2-methyl-1,2,3-triazole (iso- DAMTR);
6. Nitratoethylnitramine (NENA) based plasticisers, as follows:
   a. Methyl-NENA (*CAS 17096-47-8*);
   b. Ethyl-NENA (*CAS 85068-73-1*);
   c. Butyl-NENA (*CAS 82486-82-6*);
7. Dinitropropyl based plasticisers, as follows:
   a. Bis (2,2-dinitropropyl) acetal (BDNPA) (*CAS 5108-69-0*);
   b. Bis (2,2-dinitropropyl) formal (BDNPF) (*CAS 5917-61-3*);

e. Stabilisers as follows:
1. 2-Nitrodiphenylamine (*CAS 119-75-5*);
2. N-methyl-p-nitroaniline (*CAS 100-15-2*).

4.C.7. 'Gel propellants' specifically formulated for use in the systems specified in 1.A., 19.A.1. or 19.A.2.

Technical Note:

A 'gel propellant' is a fuel or oxidiser formulation using a gellant such as silicates, kaolin (clay), carbon or any polymeric gellant.

<u>N.B.</u> CAS numbers included in Item 4.C. are Technical Notes. For the use of CAS numbers in the Annex, see Introduction Section (f).

<u>Technical Note:</u>

Substance groupings in Item 4.C. (e.g. fuels, oxidisers, etc.) describe typical applications of propellant substances. A substance remains specified by Item 4.C. even when used in an application other than the typical one indicated by its grouping (e.g. hydrazinium perchlorate (CAS 27978-54-7) *is grouped as a fuel but can also be used as an oxidiser).*

4.D. SOFTWARE

4.D.1. "Software" specially designed or modified for the operation or maintenance of equipment specified in 4.B. for the "production" and handling of materials specified in 4.C.

4.E. TECHNOLOGY

4.E.1 "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or materials specified in 4.B. and 4.C.

CATEGORY II; ITEM 5

RESERVED FOR FUTURE USE

ITEM 6 PRODUCTION OF STRUCTURAL COMPOSITES, PYROLYTIC DEPOSITION AND DENSIFICATION, AND STRUCTURAL MATERIALS

6.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

6.A.1. Composite structures, laminates, and manufactures thereof, specially designed for use in the systems specified in 1.A., 19.A.1. or 19.A.2. and the subsystems specified in 2.A. or 20.A.

6.A.2. Resaturated pyrolised (i.e. carbon-carbon) components having all of the following:

a. Designed for rocket systems; and

b. Usable in the systems specified in 1.A. or 19.A.1.

6.B. TEST AND PRODUCTION EQUIPMENT

6.B.1. Equipment for the "production" of structural composites, fibres, prepregs or preforms, usable in the systems specified in 1.A., 19.A.1. or 19.A.2., as follows, and specially designed components, and accessories therefor:

a. Filament winding machines or 'fibre/tow-placement machines', of which the motions for positioning, wrapping and winding fibres can be co-ordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous or filamentary materials, and co-ordinating and programming controls;

b. 'Tape-laying machines' of which the motions for positioning and laying tape can be co-ordinated and programmed in two or more axes, designed for the manufacture of composite airframes and missile structures;

Note:

For the purposes of 6.B.1.a. and 6.B.1.b., the following definitions apply:

1. A 'filament band' is a single continuous width of fully or partially resin-impregnated tape, tow, or fibre. Fully or partially resin-impregnated

'filament bands' include those coated with dry powder that tacks upon heating.

2. *'Fibre/tow-placement machines' and 'tape-laying machines' are machines that perform similar processes that use computer-guided heads to lay one or several 'filament bands' onto a mold to create a part or a structure. These machines have the ability to cut and restart individual 'filament band' courses during the laying process.*

3. *'Fibre/tow-placement machines' have the ability to place one or more 'filament bands' having widths less than or equal to 25.4 mm. This refers to the minimum width of material the machine can place, regardless of the upper capability of the machine.*

4. *'Tape-laying machines' have the ability to place one or more 'filament bands' having widths less than or equal to 304.8 mm, but cannot place 'filaments bands' with a width equal to or less than 25.4 mm. This refers to the minimum width of material the machine can place, regardless of the upper capability of the machine.*

c. Multi-directional, multi-dimensional weaving machines or interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibres to manufacture composite structures;

<u>*Note:*</u>

6.B.1.c. does not control textile machinery not modified for the end-uses stated.

d. Equipment designed or modified for the production of fibrous or filamentary materials as follows:
   1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, or polycarbosilane) including special provision to strain the fibre during heating;
   2. Equipment for the vapour deposition of elements or compounds on heated filament substrates;
   3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);

e. Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms, including rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

Note:

Examples of components and accessories for the machines specified in 6.B.1. are moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.

6.B.2. Nozzles specially designed for the processes referred to in 6.E.3.

6.B.3. Isostatic presses having all of the following characteristics:

a. Maximum working pressure equal to or greater than 69 MPa;

b. Designed to achieve and maintain a controlled thermal environment of $600^{o}C$ or greater; and

c. Possessing a chamber cavity with an inside diameter of 254 mm or greater.

6.B.4. Chemical vapour deposition furnaces designed or modified for the densification of carbon-carbon composites.

6.B.5. Equipment and process controls, other than those specified in 6.B.3. or 6.B.4., designed or modified for densification and pyrolysis of structural composite rocket nozzles and re-entry vehicle nose tips.

6.C. MATERIALS

6.C.1. Resin impregnated fibre prepregs and metal coated fibre preforms, for the goods specified in 6.A.1., made either with organic matrix or metal matrix utilising fibrous or filamentary reinforcements having a specific tensile strength greater than 7.62×10^4 m and a specific modulus greater than 3.18×10^6 m.

Note:

The only resin impregnated fibre prepregs specified in 6.C.1. are those using resins with a glass transition temperature (Tg), after cure, exceeding 145°C as determined by ASTM D4065 or national equivalents.

<u>Technical Notes:</u>

1. In Item 6.C.1. 'specific tensile strength' is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3, measured at a temperature of (296 ± 2)K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

2. In Item 6.C.1. 'specific modulus' is the Young's modulus in N/m^2 divided by the specific weight in N/m^3, measured at a temperature of (296 ± 2)K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

6.C.2. Resaturated pyrolised (i.e. carbon-carbon) materials having all of the following:

a. Designed for rocket systems; <u>and</u>

b. Usable in the systems specified in 1.A. or 19.A.1.

6.C.3. Fine grain graphites with a bulk density of at least 1.72 g/cc measured at 15ºC and having a grain size of 100 x 10^{-6} m (100 µm) or less, usable for rocket nozzles and re-entry vehicle nose tips, which can be machined to any of the following products:

a. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;

b. Tubes having an inner diameter of 65 mm or greater and a wall thickness of 25 mm or greater and a length of 50 mm or greater; <u>or</u>

c. Blocks having a size of 120 mm x 120 mm x 50 mm or greater.

6.C.4. Pyrolytic or fibrous reinforced graphites usable for rocket nozzles and re-entry vehicle nose tips usable in systems specified in 1.A. or 19.A.1.

6.C.5. Ceramic composite materials (dielectric constant less than 6 at any frequency from 100 MHz to 100 GHz) for use in missile radomes usable in systems specified in 1.A. or 19.A.1.

6.C.6. High-temperature ceramic materials as follows:

a. Bulk machinable silicon-carbide reinforced unfired ceramic usable for nose tips usable in systems specified in 1.A. or 19.A.1.;

b. Reinforced silicon-carbide ceramic composites usable for nose tips, re-entry vehicles, nozzle flaps, usable in systems specified in 1.A. or 19.A.1.

c. Bulk machinable ceramic composite materials consisting of an 'Ultra High Temperature Ceramic (UHTC)' matrix with a melting point equal to or greater than 3000°C and reinforced with fibres or filaments, usable for missile components (such as nose-tips, re-entry vehicles, leading edges, jet vanes, control surfaces or rocket motor throat inserts) in the systems specified in 1.A., 19.A.1. or 19.A.2.

Note:

Item 6.C.6.c. does not control 'Ultra High Temperature Ceramic (UHTC)' materials in non-composite form.

Technical Note:

'Ultra High Temperature Ceramics (UHTC)' includes:

1. *Titanium diboride (TiB2);*
2. *Zirconium diboride (ZrB2);*
3. *Niobium diboride (NbB2);*
4. *Hafnium diboride (HfB2);*
5. *Tantalum diboride (TaB2);*
6. *Titanium carbide (TiC);*
7. *Zirconium carbide (ZrC);*
8. *Niobium carbide (NbC);*
9. *Hafnium carbide (HfC);*
10. *Tantalum carbide (TaC).*

6.C.7. Materials for the fabrication of missile components in the systems specified in 1.A., 19.A.1. or 19.A.2, as follows:.

a. Tungsten and alloys in particulate form with a tungsten content of 97% by weight or more and a particle size of 50 x10^{-6} m (50 µm) or less;

b. Molybdenum and alloys in particulate form with a molybdenum content of 97% by weight or more and a particle size of 50 x10^{-6} m (50 µm) or less;

c. Tungsten materials in the solid form having all of the following:

1. Any of the following material compositions:
   i. Tungsten and alloys containing 97% by weight or more of tungsten;
   ii. Copper infiltrated tungsten containing 80% by weight or more of tungsten; or
   iii. Silver infiltrated tungsten containing 80% by weight or more of tungsten; and
2. Able to be machined to any of the following products:
   i. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;
   ii. Tubes having an inner diameter of 65 mm or greater and a wall thickness of 25 mm or greater and a length of 50 mm or greater; or
   iii. Blocks having a size of 120 mm x 120 mm x 50 mm or greater.

6.C.8. Maraging steels, usable in the systems specified in 1.A. or 19.A.1., having all of the following:

a. Having an ultimate tensile strength, measured at 20°C, equal to or greater than:
   1. 0.9 GPa in the solution annealed stage; or
   2. 1.5 GPa in the precipitation hardened stage; and
b. Any of the following forms:
   1. Sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm; or
   2. Tubular forms with a wall thickness equal to or less than 50 mm and having an inner diameter equal to or greater than 270 mm.

Technical Note:

Maraging steels are iron alloys:

a. Generally characterised by high nickel, very low carbon content and use substitutional elements or precipitates to produce strengthening and age-hardening of the alloy; and
b. Subjected to heat treatment cycles to facilitate the martensitic transformation process (solution annealed stage) and subsequently age hardened (precipitation hardened stage).

6.C.9. Titanium-stabilized duplex stainless steel (Ti-DSS) usable in the systems specified in 1.A. or 19.A.1. and having all of the following:

a. Having all of the following characteristics:
   1. Containing 17.0 - 23.0% by weight of chromium and 4.5 - 7.0% by weight of nickel;
   2. Having a titanium content of greater than 0.10% by weight; and
   3. A ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10% by volume (according to ASTM E-1181-87 or national equivalents) is austenite; and

b. Any of the following forms:
   1. Ingots or bars having a size of 100 mm or more in each dimension;
   2. Sheets having a width of 600 mm or more and a thickness of 3 mm or less; or
   3. Tubes having an outer diameter of 600 mm or more and a wall thickness of 3 mm or less.

6.D. SOFTWARE

6.D.1. "Software" specially designed or modified for the operation or maintenance of equipment specified in 6.B.1.

6.D.2. "Software" specially designed or modified for the equipment specified in 6.B.3., 6.B.4. or 6.B.5.

6.E. TECHNOLOGY

6.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6.A., 6.B., 6.C. or 6.D.

6.E.2. "Technical data" (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves when used for the production of composites or partially processed composites, usable for equipment or materials specified in 6.A. or 6.C.

6.E.3. "Technology" for the "production" of pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300^{o}C to 2,900^{o}C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including "technology" for the composition of precursor gases, flow-rates, and process control schedules and parameters.

CATEGORY II; ITEM 7

RESERVED FOR FUTURE USE

CATEGORY II; ITEM 8

<u>RESERVED FOR FUTURE USE</u>

ITEM 9 INSTRUMENTATION, NAVIGATION AND DIRECTION FINDING

9.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

9.A.1. Integrated flight instrument systems which include gyrostabilisers or automatic pilots, designed or modified for use in the systems specified in 1.A., 19.A.1. or 19.A.2. and specially designed components therefor.

9.A.2. Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, and specially designed components therefor.

9.A.3. Linear accelerometers, designed for use in inertial navigation systems or in guidance systems of all types, usable in the systems specified in 1.A., 19.A.1. or 19.A.2., having all of the following characteristics, and specially designed components therefor:

a. 'Scale factor' 'repeatability' less (better) than 1250 ppm; and
b. 'Bias' 'repeatability' less (better) than 1250 micro g.

Note:

Item 9.A.3. does not control accelerometers specially designed and developed as Measurement While Drilling (MWD) sensors for use in downhole well service operations.

Technical Notes:

1. *'Bias' is defined as the accelerometer output when no acceleration is applied.*
2. *'Scale factor' is defined as the ratio of change in output to a change in the input.*
3. *The measurement of 'bias' and 'scale factor' refers to one sigma standard deviation with respect to a fixed calibration over a period of one year.*
4. *'Repeatability' is defined according to IEEE Standard for Inertial Sensor Terminology 528-2001 in the Definitions section paragraph 2.214 titled repeatability (gyro, accelerometer) as follows: 'The closeness of agreement among repeated measurements of the same variable under the same*

operating conditions when changes in conditions or non-operating periods occur between measurements'.

9.A.4. All types of gyros usable in the systems specified in 1.A., 19.A.1 or 19.A.2., with a rated 'drift rate' 'stability' of less than 0.5 degrees (1 sigma or rms) per hour in a 1 g environment, and specially designed components therefor.

Technical Notes:

1. *'Drift rate' is defined as the component of gyro output that is functionally independent of input rotation and is expressed as an angular rate. (IEEE STD 528-2001 paragraph 2.56)*

2. *'Stability' is defined as a measure of the ability of a specific mechanism or performance coefficient to remain invariant when continuously exposed to a fixed operating condition. (This definition does not refer to dynamic or servo stability.) (IEEE STD 528-2001 paragraph 2.247)*

9.A.5. Accelerometers or gyros of any type, designed for use in inertial navigation systems or in guidance systems of all types, specified to function at acceleration levels greater than 100 g, and specially designed components therefor.

Note :

9.A.5. does not include accelerometers that are designed to measure vibration or shock.

9.A.6. 'Inertial measurement equipment or systems' using accelerometers specified in 9.A.3. or 9.A.5. or gyros specified in 9.A.4. or 9.A.5., and specially designed components therefor.

Note:

Item 9.A.6. includes:

a. *Attitude and Heading Reference Systems (AHRSs);*
b. *Gyrocompasses;*
c. *Inertial Measurement Units (IMUs);*
d. *Inertial Navigation Systems (INSs);*

e. Inertial Reference Systems (IRSs);
f. Inertial Reference Units (IRUs).

Technical Note:

'Inertial measurement equipment or systems' specified in Item 9.A.6. incorporate accelerometers or gyros to measure changes in velocity and orientation in order to determine or maintain heading or position without requiring an external reference once aligned.

9.A.7. 'Integrated navigation systems', designed or modified for the systems specified in 1.A., 19.A.1. or 19.A.2. and capable of providing a navigational accuracy of 200 m CEP or less.

Technical Note:

An 'integrated navigation system' typically incorporates all of the following components:
a. An inertial measurement device (e.g. an attitude and heading reference system, inertial reference unit, or inertial navigation system);
b. One or more external sensors used to update the position and/or velocity, either periodically or continuously throughout the flight (e.g. satellite navigation receiver, radar altimeter, and/or Doppler radar); and
c. Integration hardware and software.

N.B. *For integration "software", see Item 9.D.4.*

9.A.8. Three axis magnetic heading sensors having all of the following characteristics, and specially designed components therefor:
a. Internal tilt compensation in pitch (+/– 90 degrees) and roll (+/– 180 degrees) axes;
b. Azimuthal accuracy better (less) than 0.5 degrees rms at latitudes of +/– 80 degrees, referenced to local magnetic field; and
c. Designed or modified to be integrated with flight control and navigation systems.

Note:

Flight control and navigation systems in Item 9.A.8. include gyrostabilisers, automatic pilots and inertial navigation systems.

9.B. TEST AND PRODUCTION EQUIPMENT

9.B.1. "Production equipment", and other test, calibration and alignment equipment, other than that described in 9.B.2., designed or modified to be used with equipment specified in 9.A.

Note:

Equipment specified in 9.B.1. includes the following:

a. For laser gyro equipment, the following equipment used to characterise mirrors, having the threshold accuracy shown or better:
1. Scatterometer (10 ppm);
2. Reflectometer (50 ppm);
3. Profilometer (5 Angstroms);

b. For other inertial equipment:
1. Inertial Measurement Unit (IMU) Module Tester;
2. IMU Platform Tester;
3. IMU Stable Element Handling Fixture;
4. IMU Platform Balance Fixture;
5. Gyro Tuning Test Station;
6. Gyro Dynamic Balance Station;
7. Gyro Run-In/Motor Test Station;
8. Gyro Evacuation and Filling Station;
9. Centrifuge Fixture for Gyro Bearings;
10. Accelerometer Axis Align Station;
11. Accelerometer Test Station;
12. Fibre Optic Gyro Coil Winding Machines.

9.B.2. Equipment as follows:

a. Balancing machines having all of the following characteristics:
1. Not capable of balancing rotors/assemblies having a mass greater than 3 kg;
2. Capable of balancing rotors/assemblies at speeds greater than 12,500 rpm;
3. Capable of correcting unbalance in two planes or more; and

4. Capable of balancing to a residual specific unbalance of 0.2 g mm per kg of rotor mass;

b. Indicator heads (sometimes known as balancing instrumentation) designed or modified for use with machines specified in 9.B.2.a.;

c. Motion simulators/rate tables (equipment capable of simulating motion) having all of the following characteristics:
1. Two or more axes;
2. Designed or modified to incorporate sliprings or integrated non-contact devices capable of transferring electrical power, signal information, or both; <u>and</u>
3. Having any of the following characteristics:
a. For any single axis having all of the following:
1. Capable of rates of 400 degrees/s or more, or 30 degrees/s or less; <u>and</u>
2. A rate resolution equal to or less than 6 degrees/s and an accuracy equal to or less than 0.6 degrees/s;
b. Having a worst-case rate stability equal to or better (less) than plus or minus 0.05% averaged over 10 degrees or more; <u>or</u>
c. A positioning "accuracy" equal to or less (better) than 5 arc second;

d. Positioning tables (equipment capable of precise rotary positioning in any axes) having all of the following characteristics:
1. Two or more axes; <u>and</u>
2. A positioning "accuracy" equal to or less (better) than 5 arc second;

e. Centrifuges capable of imparting accelerations greater than 100 g and designed or modified to incorporate sliprings or integrated non-contact devices capable of transferring electrical power, signal information, or both.

<u>*Notes:*</u>

1. *The only balancing machines, indicator heads, motion simulators, rate tables, positioning tables and centrifuges specified in Item 9 are those specified in 9.B.2.*

2. *9.B.2.a. does not control balancing machines designed or modified for dental or other medical equipment.*

3. *9.B.2.c. and 9.B.2.d. do not control rotary tables designed or modified for machine tools or for medical equipment.*

4. *Rate tables not controlled by 9.B.2.c. and providing the characteristics of a positioning table are to be evaluated according to 9.B.2.d.*

5. *Equipment that has the characteristics specified in 9.B.2.d. which also meets the characteristics of 9.B.2.c. will be treated as equipment specified in 9.B.2.c.*

6. *Item 9.B.2.c. applies whether or not sliprings or integrated non-contact devices are fitted at the time of export.*

7. *Item 9.B.2.e. applies whether or not sliprings or integrated non-contact devices are fitted at the time of export.*

9.C. MATERIALS

None.

9.D. SOFTWARE

9.D.1. "Software" specially designed or modified for the "use" of equipment specified in 9.A. or 9.B.

9.D.2. Integration "software" for the equipment specified in 9.A.1.

9.D.3. Integration "software" specially designed for the equipment specified in 9.A.6.

9.D.4. Integration "software", designed or modified for the 'integrated navigation systems' specified in 9.A.7.

Note:

A common form of integration "software" employs Kalman filtering.

9.E. TECHNOLOGY

9.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 9.A., 9.B. or 9.D.

Note:

Equipment or "software" specified in 9.A. or 9.D. may be exported as part of a manned aircraft, satellite, land vehicle, marine/submarine vessel or geophysical survey equipment or in quantities appropriate for replacement parts for such applications.

ITEM 10 FLIGHT CONTROL

10.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

10.A.1. Pneumatic, hydraulic, mechanical, electro-optical, or electromechanical flight control systems (including fly-by-wire and fly-by-light systems) designed or modified for the systems specified in 1.A.

10.A.2. Attitude control equipment designed or modified for the systems specified in 1.A.

10.A.3. Flight control servo valves designed or modified for the systems in 10.A.1. or 10.A.2., and designed or modified to operate in a vibration environment greater than 10 g rms between 20 Hz and 2 kHz.

Notes:

1. Systems, equipment or valves specified in 10.A. may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.
2. For conversion of manned aircraft to operate as unmanned aerial vehicles specified in 1.A.2., Item 10.A. includes the systems, equipment and valves designed or modified to enable operation of manned aircraft as unmanned aerial vehicles.

10.B. TEST AND PRODUCTION EQUIPMENT

10.B.1. Test, calibration, and alignment equipment specially designed for equipment specified in 10.A.

10.C. MATERIALS

None.

10.D. SOFTWARE

10.D.1. "Software" specially designed or modified for the "use" of equipment specified in 10.A. or 10.B.

Note:

"Software" specified in 10.D.1. may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

10.E. TECHNOLOGY

10.E.1. Design "technology" for integration of air vehicle fuselage, propulsion system and lifting control surfaces, designed or modified for the systems specified in 1.A.2. or 19.A.2., to optimise aerodynamic performance throughout the flight regime of an unmanned aerial vehicle.

10.E.2. Design "technology" for integration of the flight control, guidance, and propulsion data into a flight management system, designed or modified for the systems specified in 1.A.1. or 19.A.1., for optimisation of rocket system trajectory.

10.E.3. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 10.A., 10.B. or 10.D.

ITEM 11 AVIONICS

11.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

11.A.1. Radar and laser radar systems, including altimeters, designed or modified for use in the systems specified in 1.A.

Technical Note:

Laser radar systems embody specialised transmission, scanning, receiving and signal processing techniques for utilisation of lasers for echo ranging, direction finding and discrimination of targets by location, radial speed and body reflection characteristics.

11.A.2. Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics, designed or modified for use in the systems specified in 1.A.

11.A.3. Receiving equipment for 'navigation satellite systems', having any of the following characteristics, and specially designed components therefor:

a. Designed or modified for use in systems specified in 1.A.; or

b. Designed or modified for airborne applications and having any of the following:
   1. Capable of providing navigation information at speeds in excess of 600 m/s;
   2. Employing decryption, designed or modified for military or governmental services, to gain access to a 'navigation satellite system' secure signal/data; or
   3. Being specially designed to employ anti-jam features (e.g. null steering antenna or electronically steerable antenna) to function in an environment of active or passive countermeasures.

Note:

11.A.3.b.2. and 11.A.3.b.3. do not control equipment designed for commercial, civil or 'Safety of Life' (e.g. data integrity, flight safety) 'navigation satellite system' services.

<u>*Technical Note:*</u>

In Item 11.A.3., 'navigation satellite system' includes Global Navigation Satellite Systems (GNSS; e.g. GPS, GLONASS, Galileo or BeiDou) and Regional Navigation Satellite Systems (RNSS; e.g. NavIC, QZSS).

11.A.4. Electronic assemblies and components, designed or modified for use in the systems specified in 1.A. or 19.A. and specially designed for military use and operation at temperatures in excess of 125°C.

<u>*Note:*</u>

Equipment specified in 11.A.1., 11.A.2., 11.A.3. and 11.A.4. includes the following:
a. Terrain contour mapping equipment;
b. Scene mapping and correlation (both digital and analogue) equipment;
c. Doppler navigation radar equipment;
d. Passive interferometer equipment;
e. Imaging sensor equipment (both active and passive).

11.A.5. Umbilical and interstage electrical connectors specially designed for systems specified in 1.A.1. or 19.A.1.

<u>*Technical Note:*</u>

Interstage connectors referred to in 11.A.5. also include electrical connectors installed between systems specified in 1.A.1. or 19.A.1. and their "payload".

<u>*Note:*</u>

Equipment specified in 11.A. may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

11.B. TEST AND PRODUCTION EQUIPMENT

None.

11.C. MATERIALS

None.

11.D. SOFTWARE

11.D.1. "Software" specially designed or modified for the "use" of equipment specified in 11.A.1., 11.A.2. or 11.A.4.

11.D.2. "Software" specially designed for the "use" of equipment specified in 11.A.3.

11.E. TECHNOLOGY

11.E.1. Design "technology" for protection of avionics and electrical subsystems against Electromagnetic Pulse (EMP) and Electromagnetic Interference (EMI) hazards from external sources, as follows:

a. Design "technology" for shielding systems;

b. Design "technology" for the configuration of hardened electrical circuits and subsystems;

c. Design "technology" for determination of hardening criteria for the above.

11.E.2. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 11.A. or 11.D.

ITEM 12 LAUNCH SUPPORT

12.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

12.A.1. Apparatus and devices, designed or modified for the handling, control, activation and launching of the systems specified in 1.A., 19.A.1. or 19.A.2.

12.A.2. Vehicles designed or modified for the transport, handling, control, activation and launching of the systems specified in 1.A.

12.A.3. Gravity meters (gravimeters) or gravity gradiometers, designed or modified for airborne or marine use, usable for systems specified in 1.A., as follows, and specially designed components therefor:

a. Gravity meters having all of the following characteristics:
1. A static or operational accuracy equal to or less (better) than 0.7 milligal (mgal); and
2. A 'time to steady-state registration' of two minutes or less;

Technical Note:

In Item 12.A.3.a.2., 'time to steady-state registration' (also referred to as the gravity meter's response time) is the time over which the disturbing effects of platform-induced acceleration (high frequency noise) are reduced.

b. Gravity gradiometers.

12.A.4. Telemetry and telecontrol equipment, including ground equipment, designed or modified for systems specified in 1.A., 19.A.1. or 19.A.2.

Notes:

1. 12.A.4. does not control equipment designed or modified for manned aircraft or satellites.

2. 12.A.4. does not control ground based equipment designed or modified for terrestrial or marine applications.

3. 12.A.4. does not control equipment designed for commercial, civil or 'Safety of Life' (e.g. data integrity, flight safety) GNSS services.

12.A.5. Precision tracking systems, usable for systems specified in 1.A., 19.A.1. or 19.A.2. as follows:

a. Tracking systems which use a code translator installed on the rocket or unmanned aerial vehicle in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of inflight position and velocity;

b. Range instrumentation radars including associated optical/infrared trackers with all of the following capabilities:
1. Angular resolution better than 1.5 mrad;
2. Range of 30 km or greater with a range resolution better than 10 m rms; and
3. Velocity resolution better than 3 m/s.

12.A.6. Thermal batteries designed or modified for the systems specified in 1.A., 19.A.1. or 19.A.2.

Note:

Item 12.A.6. does not control thermal batteries specially designed for rocket systems or unmanned aerial vehicles that are not capable of a "range" equal to or greater than 300 km.

Technical Note:

Thermal batteries are single use batteries that contain a solid non-conducting inorganic salt as the electrolyte. These batteries incorporate a pyrolytic material that, when ignited, melts the electrolyte and activates the battery.

12.B. TEST AND PRODUCTION EQUIPMENT

None.

12.C. MATERIALS

None.

12.D. SOFTWARE

12.D.1. "Software" specially designed or modified for the "use" of equipment specified in 12.A.1.

12.D.2. "Software" which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path, specially designed or modified for systems specified in 1.A., 19.A.1. or 19.A.2.

12.D.3. "Software" specially designed or modified for the "use" of equipment specified in 12.A.4. or 12.A.5., usable for systems specified in 1.A., 19.A.1. or 19.A.2.

12.E. TECHNOLOGY

12.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 12.A. or 12.D.

ITEM 13 COMPUTERS

13.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

13.A.1. Analogue computers, digital computers or digital differential analysers, designed or modified for use in the systems specified in 1.A., having any of the following characteristics:

a. Rated for continuous operation at temperatures from below -45°C to above +55°C; or

b. Designed as ruggedised or "radiation hardened".

13.B. TEST AND PRODUCTION EQUIPMENT

None.

13.C. MATERIALS

None.

13.D. SOFTWARE

None.

13.E. TECHNOLOGY

13.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 13.A.

Note:

Item 13 equipment may be exported as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

ITEM 14 ANALOGUE TO DIGITAL CONVERTERS

14.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

14.A.1. Analogue-to-digital converters, usable in the systems specified in 1.A., having any of the following characteristics:

a. Designed to meet military specifications for ruggedised equipment; or

b. Designed or modified for military use and being any of the following types:
1. Analogue-to-digital converter "microcircuits", which are "radiation-hardened" or have all of the following characteristics:
a. Rated for operation in the temperature range from below –54°C to above +125°C; and
b. Hermetically sealed; or
2. Electrical input type analogue-to-digital converter printed circuit boards or modules, having all of the following characteristics:
a. Rated for operation in the temperature range from below -45°C to above +80°C; and
b. Incorporating "microcircuits" specified in 14.A.1.b.1.

14.B. TEST AND PRODUCTION EQUIPMENT

None.

14.C. MATERIALS

None.

14.D. SOFTWARE

None.

14.E. TECHNOLOGY

14.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 14.A.

ITEM 15 TEST FACILITIES AND EQUIPMENT

15.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

None.

15.B. TEST AND PRODUCTION EQUIPMENT

15.B.1. Vibration test equipment, usable for the systems specified in 1.A., 19.A.1. or 19.A.2. or the subsystems specified in 2.A. or 20.A., and components therefor, as follows:

a. Vibration test systems employing feedback or closed loop techniques and incorporating a digital controller, capable of vibrating a system at an acceleration equal to or greater than 10 g rms between 20 Hz and 2 kHz while imparting forces equal to or greater than 50 kN, measured 'bare table';

b. Digital controllers, combined with specially designed vibration test "software", with a 'real-time control bandwidth' greater than 5 kHz and designed for use with vibration test systems specified in 15.B.1.a.;

Technical Note:

'Real-time control bandwidth' is defined as the maximum rate at which a controller can execute complete cycles of sampling, processing data and transmitting control signals.

c. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force equal to or greater than 50 kN, measured 'bare table', and usable in vibration test systems specified in 15.B.1.a.;

d. Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force equal to or greater than 50 kN, measured 'bare table', and usable in vibration test systems specified in 15.B.1.a.

Technical Note:

Vibration test systems incorporating a digital controller are those systems, the functions of which are, partly or entirely, automatically controlled by stored and digitally coded electrical signals.

15.B.2. 'Aerodynamic test facilities' for speeds of Mach 0.9 or more, usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A. or 20.A.

Note:

Item 15.B.2 does not control wind tunnels for speeds of Mach 3 or less with dimension of the 'test cross section size' equal to or less than 250 mm.

Technical Notes:

1. *'Aerodynamic test facilities' includes wind tunnels and shock tunnels for the study of airflow over objects.*

2. *'Test cross section size' means the diameter of the circle, or the side of the square, or the longest side of the rectangle, or the major axis of the ellipse at the largest 'test cross section' location. 'Test cross section' is the section perpendicular to the flow direction.*

15.B.3. Test benches **or test** stands, usable for the systems specified in 1.A., 19.A.1. or 19.A.2. or the subsystems specified in 2.A. or 20.A., which have the capacity to handle solid or liquid propellant rockets, motors or engines having a thrust greater than 68 kN, or which are capable of simultaneously measuring the three axial thrust components.

15.B.4. Environmental chambers as follows, usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A. or 20.A.:

a. Environmental chambers having all of the following characteristics:
   1. Capable of simulating any of the following flight conditions:
      a. Altitude equal to or greater than 15 km; or
      b. Temperature range from below –50ºC to above 125ºC; and

   2. Incorporating, or designed or modified to incorporate, a shaker unit or other vibration test equipment to produce vibration environments

equal to or greater than 10 g rms, measured 'bare table', between 20 Hz and 2 kHz while imparting forces equal to or greater than 5 kN;

Technical Notes:

1. *Item 15.B.4.a.2. describes systems that are capable of generating a vibration environment with a single wave (e.g. a sine wave) and systems capable of generating a broad band random vibration (i.e. power spectrum).*

2. *In Item 15.B.4.a.2., designed or modified means the environmental chamber provides appropriate interfaces (e.g. sealing devices) to incorporate a shaker unit or other vibration test equipment as specified in this Item.*

b. Environmental chambers capable of simulating all of the following flight conditions:
   1. Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 2 x 10^{-5} N/m^2) or with a total rated acoustic power output of 4 kW or greater; and
   2. Any of the following:
      a. Altitude equal to or greater than 15 km; or
      b. Temperature range from below -50°C to above 125°C.

15.B.5. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and equipment containing those accelerators, usable for the systems specified in 1.A., 19.A.1. or 19.A.2. or the subsystems specified in 2.A. or 20.A.

Note:

15.B.5. does not control equipment specially designed for medical purposes.

Technical Note:

In Item 15.B. 'bare table' means a flat table, or surface, with no fixture or fittings.

15.B.6. 'Aerothermodynamic test facilities', usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A. or 20.A., having any of the following characteristics:

a. an electrical power supply equal to or greater than 5 MW; or
b. a gas supply total pressure equal to or greater than 3 MPa.

Technical note:

'Aerothermodynamic test facilities' include plasma arc jet facilities and plasma wind tunnels for the study of thermal and mechanical effects of airflow on objects.

15.C. MATERIALS

None.

15.D. SOFTWARE

15.D.1. "Software" specially designed or modified for the "use" of equipment specified in 15.B. usable for testing systems specified in 1.A., 19.A.1. or 19.A.2. or subsystems specified in 2.A. or 20.A.

15.E. TECHNOLOGY

15.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 15.B. or 15.D.

ITEM 16 MODELLING-SIMULATION AND DESIGN INTEGRATION

16.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

16.A.1. Specially designed hybrid (combined analogue/digital) computers for modelling, simulation or design integration of systems specified in 1.A. or the subsystems specified in 2.A.

Note:

This control only applies when the equipment is supplied with "software" specified in 16.D.1.

16.B. TEST AND PRODUCTION EQUIPMENT

None.

16.C. MATERIALS

None.

16.D. SOFTWARE

16.D.1. "Software" specially designed for modelling, simulation, or design integration of the systems specified in 1.A. or the subsystems specified in 2.A or 20.A.

Technical Note:

The modelling includes in particular the aerodynamic and thermodynamic analysis of the systems.

16.E. TECHNOLOGY

16.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 16.A. or 16.D.

ITEM 17 STEALTH

17.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

17.A.1. Devices for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A. or 20.A.

17.B. TEST AND PRODUCTION EQUIPMENT

17.B.1. Systems, specially designed for radar cross section measurement, usable for the systems specified in 1.A., 19.A.1. or 19.A.2. or the subsystems specified in 2.A.

17.C. MATERIALS

17.C.1. Materials for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A.

Notes:

1. *17.C.1. includes structural materials and coatings (including paints), specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet spectra.*

2. *17.C.1. does not control coatings (including paints) when specially used for thermal control of satellites.*

17.D. SOFTWARE

17.D.1. "Software" specially designed for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 1.A. or 19.A. or the subsystems specified in 2.A.

Note:

17.D.1. includes "software" specially designed for analysis of signature reduction.

17.E. TECHNOLOGY

17.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 17.A., 17.B., 17.C. or 17.D.

Note:

17.E.1. includes databases specially designed for analysis of signature reduction.

ITEM 18 NUCLEAR EFFECTS PROTECTION

18.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

18.A.1. "Radiation Hardened" "microcircuits" usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 1.A.

18.A.2. 'Detectors' specially designed or modified to protect rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 1.A.

Technical Note:

A 'detector' is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material. This includes devices that sense by one time operation or failure.

18.A.3. Radomes designed to withstand a combined thermal shock greater than 4.184×10^6 J/m^2 accompanied by a peak over pressure of greater than 50 kPa, usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 1.A.

18.B. TEST AND PRODUCTION EQUIPMENT

None.

18.C. MATERIALS

None.

18.D. SOFTWARE

None.

18.E. TECHNOLOGY

18.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 18.A.

ITEM 19 OTHER COMPLETE DELIVERY SYSTEMS

19.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

19.A.1. Complete rocket systems (including ballistic missiles, space launch vehicles, and sounding rockets), not specified in 1.A.1., capable of a "range" equal to or greater than 300 km.

19.A.2. Complete unmanned aerial vehicle systems (including cruise missiles, target drones and reconnaissance drones), not specified in 1.A.2., capable of a "range" equal to or greater than 300 km.

19.A.3. Complete unmanned aerial vehicle systems, not specified in 1.A.2. or 19.A.2., having all of the following:

a. Having any of the following:
   1. An autonomous flight control and navigation capability; or
   2. Capability of controlled flight out of the direct vision range involving a human operator; and

b. Having any of the following:
   1. Incorporating an aerosol dispensing system/mechanism with a capacity greater than 20 litres; or
   2. Designed or modified to incorporate an aerosol dispensing system/mechanism with a capacity greater than 20 litres.

Note:

Item 19.A.3. does not control model aircraft, specially designed for recreational or competition purposes.

Technical Notes:

1. An aerosol consists of particulate or liquids other than fuel components, by-products or additives, as part of the "payload" to be dispersed in the atmosphere. Examples of aerosols include pesticides for crop dusting and dry chemicals for cloud seeding.

2. An aerosol dispensing system/mechanism contains all those devices (mechanical, electrical, hydraulic, etc.), which are necessary for storage and dispersion of an aerosol into the atmosphere. This includes the possibility of aerosol injection into the combustion exhaust vapour and into the propeller slip stream.

19.B. TEST AND PRODUCTION EQUIPMENT

19.B.1. "Production facilities" specially designed for the systems specified in 19.A.1 or 19.A.2.

19.C. MATERIALS

None.

19.D. SOFTWARE

19.D.1. "Software" which coordinates the function of more than one subsystem, specially designed or modified for "use" in the systems specified in 19.A.1. or 19.A.2.

Note:

For a manned aircraft converted to operate as an unmanned aerial vehicle specified in 19.A.2., Item 19.D.1. includes "software", as follows:

a. "Software" specially designed or modified to integrate the conversion equipment with the aircraft system functions;
b. "Software" specially designed or modified to operate the aircraft as an unmanned aerial vehicle.

19.E. TECHNOLOGY

19.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 19.A. 1. or 19.A.2.

ITEM 20 OTHER COMPLETE SUBSYSTEMS

20.A. EQUIPMENT, ASSEMBLIES AND COMPONENTS

20.A.1. Complete subsystems as follows:

a. Individual rocket stages, not specified in 2.A.1., usable in systems specified in 19.A.;

b. Rocket propulsion subsystems, not specified in 2.A.1., usable in the systems specified in 19.A.1., as follows:
   1. Solid propellant rocket motors or hybrid rocket motors having a total impulse capacity equal to or greater than 8.41×10^5 Ns, but less than 1.1×10^6 Ns;
   2. Liquid propellant rocket engines or gel propellant rocket motors integrated, or designed or modified to be integrated, into a liquid propellant or gel propellant propulsion system which has a total impulse capacity equal to or greater than 8.41×10^5 Ns, but less than 1.1×10^6 Ns;

20.B. TEST AND PRODUCTION EQUIPMENT

20.B.1. "Production facilities" specially designed for the subsystems specified in 20.A.

20.B.2. "Production equipment" specially designed for the subsystems specified in 20.A.

20.C. MATERIALS

None.

20.D. SOFTWARE

20.D.1. "Software" specially designed or modified for the systems specified in 20.B.1.

20.D.2. "Software", not specified in 2.D.2., specially designed or modified for the "use" of rocket motors or engines specified in 20.A.1.b.

20.E. TECHNOLOGY

20.E.1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 20.A., 20.B. or 20.D.

UNITS, CONSTANTS, ACRONYMS AND ABBREVIATIONS USED IN THIS ANNEX

ABEC	Annular Bearing Engineers Committee
ABMA	American Bearing Manufactures Association
ANSI	American National Standards Institute
Angstrom	1 x 10^{-10} metre
ASTM	American Society for Testing and Materials
bar	unit of pressure
°C	degree Celsius
cc	cubic centimetre
CAS	Chemical Abstracts Service
CEP	Circular Error Probable or Circle of Equal Probability
dB	decibel
g	gram; also, acceleration due to gravity
GHz	gigahertz
GNSS	Global Navigation Satellite System e.g. 'BeiDou' 'Galileo' 'GLONASS' – Global’naya Navigatsionnaya Sputnikovaya Sistema 'GPS' – Global Positioning System
h	hour
Hz	hertz
HTPB	Hydroxy–Terminated Polybutadiene
ICAO	International Civil Aviation Organisation
IEEE	Institute of Electrical and Electronic Engineers
IR	Infrared
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industrial Standard
K	Kelvin
kg	kilogram
kHz	kilohertz
km	kilometre
kN	kilonewton
kPa	kilopascal
kW	kilowatt
m	metre
MeV	million electron volt or mega electron volt
MHz	megahertz
milligal	10^{-5} m/s^2 (also called mGal, mgal or milligalileo)
mm	millimetre
mm Hg	mm of mercury
MPa	megapascal
mrad	milliradian
ms	millisecond

µm	micrometre
N	newton
Pa	pascal
ppm	parts per million
rads (Si)	radiation absorbed dose
RF	radio frequency
rms	root mean square
RNSS	Regional Navigation Satellite System e.g.
	'NavIC' – Indian Regional Navigation Satellite System
	'QZSS' – Quasi Zenith Satellite System
rpm	revolutions per minute
RV	Re-entry Vehicles
s	second
Tg	glass transition temperature
Tyler	Tyler mesh size, or Tyler standard sieve series
UAV	Unmanned Aerial Vehicle
UV	Ultra violet

TABLE OF CONVERSIONS

TABLE OF CONVERSIONS USED IN THIS ANNEX		
Unit (from)	Unit (to)	Conversion
bar	pascal (Pa)	1 bar = 100 kPa
g (gravity)	m/s^2	1 g = 9.806 65 m/s^2
mrad (millirad)	degrees (angle)	1 mrad ≈ 0.0573°
rads	ergs/gram of Si	1 rad (Si) = 100 ergs/gram of silicon (= 0.01 gray [Gy])
Tyler 250 mesh	mm	for a Tyler 250 mesh, mesh opening 0.063 mm

ADDENDUM – STATEMENT OF UNDERSTANDING

Statement of Understanding

Members agree that, in those cases where the term "national equivalents" are specifically allowed as alternatives to specified International Standards, the technical methods and parameters embodied in the national equivalent would ensure that the requirements of the standard set by the specified International Standards are met.